

# ORION FLIGHT TEST-1 THERMAL PROTECTION SYSTEM INSTRUMENTATION

**T. John Kowal<sup>(1)</sup>**

*<sup>(1)</sup>NASA Johnson Space Center, Mail Code ES3, Houston, Texas 77058, Email: john.kowal@nasa.gov*

The Orion Crew Exploration Vehicle (CEV) was originally under development to provide crew transport to the International Space Station after the retirement of the Space Shuttle, and to provide a means for the eventual return of astronauts to the Moon. With the current changes in the future direction of the United States' human exploration programs, the focus of the Orion project has shifted to the project's first orbital flight test, designated Orion Flight Test 1 (OFT-1). The OFT-1 is currently planned for launch in July 2013 and will demonstrate the Orion vehicle's capability for performing missions in low Earth orbit (LEO), as well as extensibility beyond LEO for select, critical areas.

Among the key flight test objectives are those related to validation of the re-entry aerodynamic and aerothermal environments, and the performance of the thermal protection system (TPS) when exposed to these environments. A specific flight test trajectory has been selected to provide a high energy entry beyond that which would be experienced during a typical low Earth orbit return, given the constraints imposed by the possible launch vehicles. This trajectory resulted from a trade study that considered the relative benefit of conflicting objectives from multiple subsystems, and sought to provide the maximum integrated benefit to the re-entry state-of-the-art. In particular, the trajectory was designed to provide: a significant, measureable radiative heat flux to the windward surface; data on boundary transition from laminar to turbulent flow; and data on catalytic heating overshoot on non-ablating TPS.

In order to obtain the necessary flight test data during OFT-1, the vehicle will need to have an adequate quantity of instrumentation. A collection of instrumentation is being developed for integration in the OFT-1 TPS. In part, this instrumentation builds upon the work performed for the Mars Science Laboratory Entry, Descent and Landing Instrument (MEDLI) suite to instrument the OFT-1 ablative heat shield. The MEDLI integrated sensor plugs and pressure sensors will be adapted for compatibility with the Orion TPS design. The sensor plugs will provide in-depth temperature data to support aerothermal and TPS model correlation, and the pressure sensors will provide a flush air data system for validation of the entry and descent aerodynamic environments. In addition, a radiometer design will be matured to measure the radiative component of the reentry heating at two locations on the heat shield. For the back shell, surface thermocouple and pressure port designs will be developed and applied which build upon the heritage of the Space Shuttle Program for instrumentation of reusable surface insulation (RSI) tiles.

The quantity and location of the sensors has been determined to balance the needs of the reentry disciplines with the demands of the hardware development, manufacturing and integration. Measurements which provided low relative value and presented significant engineering development effort were, unfortunately, eliminated. The final TPS instrumentation has been optimized to target priority test objectives. The data obtained will serve to provide a better understanding of reentry environments for the Orion capsule design, reduce margins, and potentially reduce TPS mass or provide TPS extensibility for alternative missions.